Summary of SEPUP-related Research

Introduction to SEPUP

SEPUP began in 1983 as a not-for-profit project to develop hands-on materials about chemicals and their use for schools and community groups. It was initially called CEPUP (Chemical Education for Public Understanding Program). In 1987 CEPUP received its first funding from the National Science Foundation (NSF) to develop twelve issue-oriented modules on topics such as water pollution, household chemicals, and food additives.

As the mission of the project expanded to include other scientific disciplines and the development of year-long courses for the secondary grades, the name of the project changed to SEPUP (Science Education for Public Understanding Program). The NSF is currently the primary funding source for SEPUP curriculum materials development. SEPUP is located at The Lawrence Hall of Science at the University of California at Berkeley.

SEPUP programs have been revised and expanded over the years and this has sometimes involved a name change. The following table summarizes how the names of SEPUP's full year programs have evolved.

Name of program	Acronym	Publication date	Grades	Note
Issues, Evidence, and You	IEY	1996	6 – 8	Revised 2003
Science and Life Issues	SALI	2001	6 – 8	
Science and Sustainability	S&S	2005	9 – 12	
Issues and Earth Science	IAES	2006	6 – 8	
Issues and Physical Science	IAPS	2007	6 – 8	Replaced IEY
Issues and Life Science	IALS	2009	6 – 8	Replaced SALI
Science and Global Issues	SGI	2011	9 – 12	Expands S&S

In this summary, reference is made to both recent and early versions of various programs and occasionally to individual SEPUP modules.

All SEPUP materials are developed using an iterative process, which involves development, piloting, and field-testing phases. Data and feedback are collected during piloting and field-testing. These data are used to inform the revisions to the program. The core components of SEPUP curriculum materials have remained the same since the inception of the program. These include:

- An instructional model
- Inquiry-based instructional strategies
- Issue-oriented science
- Strategies geared to students' learning styles
- Balance of individual and cooperative learning
- Spiraling of important concepts and skills
- Assessment system

Research findings on SEPUP

The results of 20 years of research on the SEPUP program indicates the following:

- Positive effects on student learning in the following areas:
    - Content knowledge
    - Problem-solving
    - Decision-making
    - Investigation skills
- Increased interest in science, and increased perception of the relevance of science to students' lives

In addition, research indicates that SEPUP materials can be used as a powerful professional development tool.

SEPUP has also been highlighted in several influential publications. In his book *Redesigning Education*, Kenneth G. Wilson (1994) calls SEPUP "…one of the best American examples of educational design" (p.205). Wilson, a Nobel-prize winner in physics and the former director of Project Discovery (a 5-year federally funded project to restructure K-12 mathematics and science in Ohio), has written extensively on school reform, noting that "…the [SEPUP] program develops its [materials] through a small scale version of the redesign process, from tracking basic research in education and testing prototypes in real classrooms to integrating innovations and mentoring teachers…" (p. 205).

As part of a 3-year research project at the University of Arizona, Stanley Pogrow (1993) reviewed and ranked middle school materials to identify those that were the most "creative, relevant, and rigorous." SEPUP materials were cited as exemplary and fulfilled his criteria that curriculum: 1) relate science content to issues of concern to students; 2) support a reflective, Socratic approach; 3) develop thinking skills; and 4) present content in a rigorous fashion.

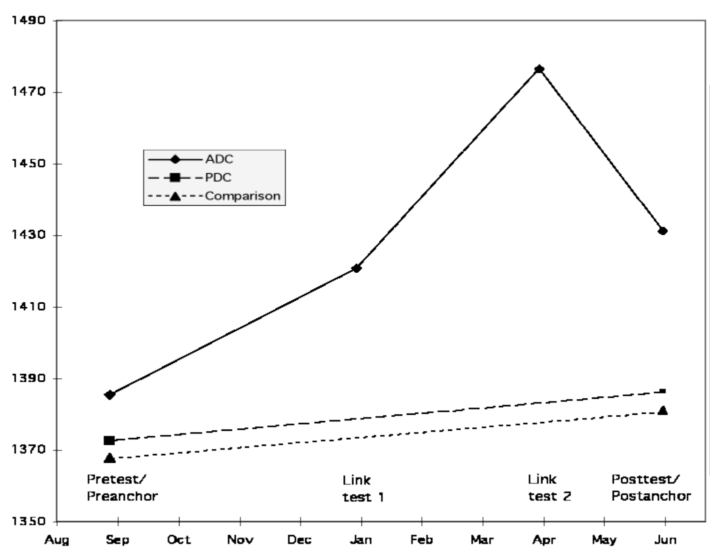
The National Science Foundation Division of Elementary, Secondary, and Informal Education used more than 40 specific criteria to review NSF-funded middle level materials. In addition to questions relating to content, the reviewers asked whether the materials "push teachers to teach differently" and "provide students the opportunity to make conjectures, gather evidence, and develop arguments to support, reject, and revise their explanations for natural phenomena" (Lewis, 1996). The examining committee recommended both SEPUP modular and full-year comprehensive programs as materials that meet these criteria, noting that "the materials are engaging, provide good activities for student decision-making and opportunities for student-designed inquiry." (NSF, 1997).

SEPUP instructional materials utilize a research-based assessment system that was developed in cooperation with the University of California Graduate School of Education. This system is recognized as "an excellent assessment component" of SEPUP materials in the NSF study cited above (NSF, 1997). In *Classroom Assessment and the National Science Education Standards* (National Research Council, 2001), the SEPUP assessment system is presented as a strong example of a system that can be used for both formative and summative assessment. Materials included in a SEPUP Teacher's Guide, such as scoring guides (or rubrics), are reproduced in the book for general use.

Positive effects on student learning
A study by Wilson and Sloane (2000) measured the progress of three different groups of middle school science students over the course of a year. The comparison group of students did not use SEPUP while the other two groups used *Issues, Evidence and You* (IEY). The PDC group used IEY without the assessment system whereas the ADC group used the assessment system.

The results of the study are shown in Figure 1. Group comparisons were made using a pretest/posttest comparison. The ADC group was evaluated at the end of each unit. The other two groups were evaluated at the beginning and end of the course. In total 63 teachers were involved in the study (26 ADC teachers, 25 PDC teachers, and 12 comparison teachers). The data represent mean scores for the three groups of students. The researchers concluded that the results for the comparison group were equivalent to a student moving from the 50th to the 59th percentile over the course of a year. The gain for the ADC group is equivalent to the mean student moving from the 50th percentile to the 77th percentile over the same time period. This is a gain of 3.46 times greater than the comparison group. The researchers concluded that this was "an educationally significant change, marking the difference between a student who typically achieves partial success, and one who achieves satisfactory completion about half the time." (Wilson & Sloane, 2000)

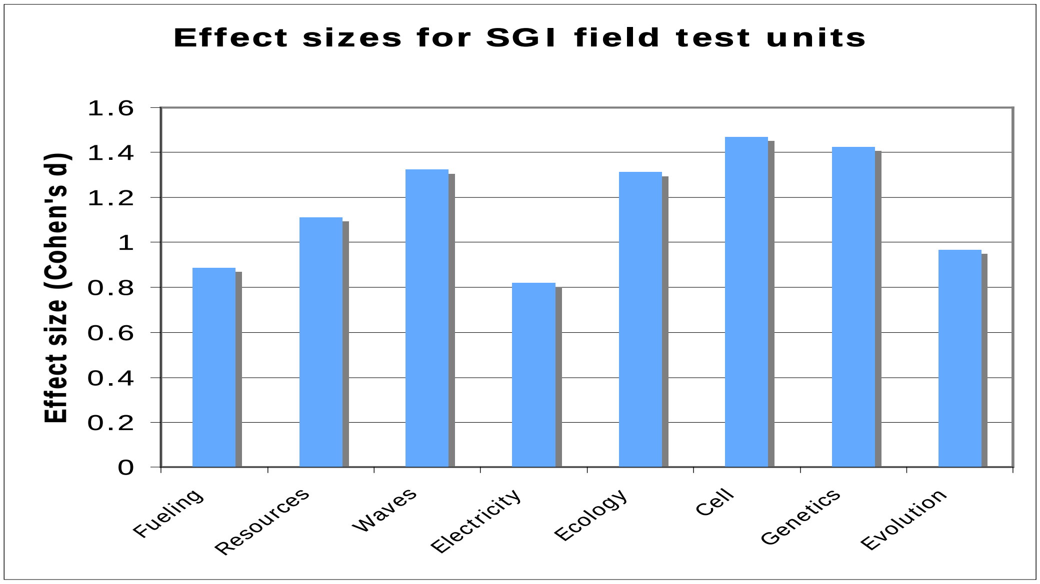
Scaled Score **Figure 1**



Gains for the Assessment Development Centers (ADC), Professional Development Centers (PDC), and comparison groups.

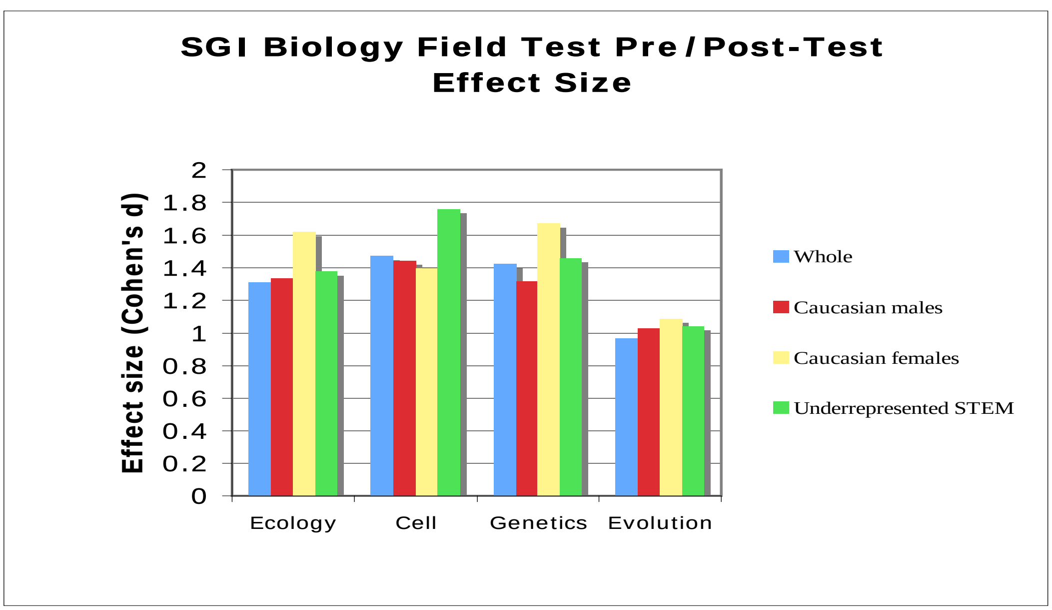
A more recent study followed the progress of students who were field-testing the high school biology and physical science units from *Science and Global Issues*. In this study students took a pre-test before beginning each unit and a post-test after completing the unit. The mean scores of the two tests were compared and the difference was expressed in terms of a Cohen's d effect size. In this system an effect size of 1.0 would indicate that the mean of the post-test scores differed from the mean of the pre-test scores by one standard deviation. Cohen labeled an effect size as small if the Cohen's d ≥ 0.20. A medium effect size would have a Cohen's d ≥ 0.50 and a large effect size Cohen's d ≥ 0.80. The results shown in Figure 2 clearly indicate that the effect sizes were large for each unit.

Figure 2



The results shown in Figure 3 represent the pre-/post-effect sizes for sub-groups for the Biology field-test units. The subgroups include Caucasian males, Caucasian females, and groups that are typically underrepresented in STEM. The data indicate a large effect size for all subgroups for each of the units. All of the tests used were based on content-standards and consisted of multiple choice and constructed response questions.

Figure 3



The Center for Research and Evaluation at the Lawrence Hall of Science had the responsibility for conducting and scoring data analyses for the I*ssues and Earth Science* curriculum 2004 – 2005 national field test. They reported the following results for the seven units of the program.

Unit	N	Mean % correct Pre-test	Mean % correct Post-test	Mean gain in % correct	Effect size (Cohen's d)
Studying Soil Scientifically	334	43	64	21	.69
Shaping the Land	207	32	53	21	.67
Rocks and Minerals	196	46	67	21	.48
Plate Tectonics	170	46	71	25	.64
Weather and Atmosphere	76	52	70	18	.62
The Earth in Space	138	34	68	34	.80
Space Exploration	123	46	69	23	.69

Reliability estimates for the pre/post –test measures ranged from 0.73 to 0.82. Effect size was calculated using Cohen's d where a small effect size is .20 to .50; a medium effect size is .50 to .80, and a large effect size is greater than 0.80. As shown in the table above the effect sizes varied from .48 to .80 indicating moderate effect sizes for most units. The conclusion of the evaluator was that the results showed consistent evidence of the effectiveness of the curriculum.

In 1995, the Los Angeles Unified School District (LAUSD) started implementing a two-year high school sequence of Integrated/Coordinated Science (ICS) classes that were substantially based on *Science and Sustainability*. The ICS students showed significant gains on the SAT9 (Stanford Achievement Test) science test (Scott, 2000). The SAT9 is a norm-referenced assessment that includes a science subtest designed to assess knowledge from life, physical, and earth and space sciences.

In addition to showing greater gains in content knowledge, several studies suggest that SEPUP students also improve more than comparable non-SEPUP students in a variety of specific skills. For example, Koker (1996) examined students' decision-making skills and found differences in student responses that generally favored SEPUP students over non-SEPUP students. He also found that SEPUP students were more likely to approach problems with empirical methods (e.g., doing tests, gathering evidence) rather than non-empirical ones (e.g., using "conventional wisdom" or rhetoric). Furthermore, Samson and Wilson (1996) found that compared to non-SEPUP students, SEPUP students not only performed better in problem-solving situations that called for scientific evidence but they also believed that science was more relevant to their lives. These SEPUP approaches can help students in future scientific as well as non-scientific contexts.

Increased interest in science and perception of science as being relevant

The results of the LAUSD study of ICS also showed higher numbers of students, and in particular underrepresented minority students, enrolling in advanced science courses after taking ICS (which contained the *Science and Sustainability* program from SEPUP). The table below shows the percentage of students who chose to take an additional (third) year of science beyond the two required by LAUSD. For each of the ethnic groups that are in shown in the table, the percentage of students enrolling in an additional science course is much higher in the ICS group that used *Science and Sustainability* than those who took the traditional first two years of science (Advanced Physical Science and chemistry).

	Percentage of students by ethnicity enrolling in a third year of science after earning a C or better in ICS2, Advanced Physical Science (APS), and chemistry	
Ethnicity	**ICS2**	**APS and chemistry**
Hispanic	53.5	35.6
African American	49.4	33.3
Asian	68.8	60.3
Caucasian	50.9	43.4

This supports the results of the study by Kelly (1991) that showed that students in classrooms using SEPUP showed significant improvements that reflected the goals and objectives of the SEPUP materials. For example, students said that SEPUP materials helped them learn about the environment, health, industry, the community, and science – all of which are investigated in SEPUP's issue-oriented approach to science instruction.

Powerful professional development tool

Teachers who use SEPUP materials often show an increase in good teaching strategies and professional leadership (Kelly 1991, Koker 1992a, 1992b). This includes cooperating with other teachers, working with college science and science education faculty, participating in professional organizations, such as the National Science Teachers Association, and collaborating with outside groups related to industry, environmental, or community concerns. SEPUP instructional materials, assessment rubrics, and moderation activities are powerful professional development tools. Several studies have found that they improve teachers' ability to assess learning as well as improve their own teaching practices such as clarifying learning goals and establishing fair standards (Roberts, Sloane, & Wilson, 1996; Roberts & Wilson, 1998).

Based on this type of evidence, some institutions have used SEPUP materials as the basis for professional development workshops for teachers. In 2001, the University of North Carolina, Chapel Hill used activities adapted from SEPUP to create a professional development program. Environmental Resource Program educator Michele Kloda, who developed and led the workshop, commented, "Our goal was to help teachers give students real-life, meaningful experiences to show them that there are things we can all do every day to help maintain a healthy environment. It is an opportunity to help teachers, and ultimately students, understand that the work taking place [in research labs] has a direct application to our lives."

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